Project Report: Extrasolar Planetary Systems and the Potential for Terrestrial Planets

Project Investigator:	**Brad Hansen**

Project Progress

Pulsar planet formation:

The planets orbiting the pulsar PSR1257+12 are the only known examples of extrasolar terrestrial mass planets. NAI–supported graduate student Thayne Currie has been modeling the evolution of protoplanetary disks in the circumpulsar environment. He has developed a numerical disk evolution code and is examining the evolution in the context of modern theories of protoplanetary disk evolution. Future work will describe the next stage of evolution, using the final gas disk profile to begin a simulation of the assembly of the final planets from smaller mass planetesimal bodies.

Comet clouds in Binary systems:

The interaction of planetesimals with giant planets leads to the ejection of smaller bodies from their original orbits and some are deposited into the Oort cloud, to return as comets. The size and extent of such a comet cloud depends on the strength of external perturbing forces that replace the effect of the giant planet perturbations. The presence of a close stellar companion results in much stronger perturbations than in the case of our solar system (in which Galactic tides are thought to play the dominant role). As such, binary systems may have much more compact comet clouds. We have begun a series of numerical simulations to quantitatively investigate this process. An observational consequence is the possibility of a greater number of comet–star impacts, which may explain anomalous atmospheric abundances in some stars, such as the DZ white dwarf stars. This project, in addition to other planetesimal evolution calculations, is being discussed with Steinn Sigurdsson, at fellow NAI institution Penn State .

Hot Jupiters

Some extrasolar Jovian planets are located very close to their parent stars and the resulting irradiation has a significant effect on their thermal balance and hydrostatic structure. At present, models for these objects are limited by the fact that most stellar/planetary models are one dimensional in nature, contrary to the inherently two– or three–dimensional structure of these objects. I am collaborating with Sara Seager and James Cho (at fellow NAI institution Carnegie Institute of Washington (CIW)) to develop a realistic model for such objects. I am adapting my stellar evolution code to make full use of the two–dimensional information from Cho's surface flow calculations as outer boundary inputs. We expect to have the first fully operational applications of this code running by the end of the summer.

Spitzer Observations

In June I was awarded time on the Spitzer Infrared Space Telescope to perform a search for `Second generation planetary systems' around a sample of evolved stars. Our sample is drawn from a list of stars that are suspected to be the remnants of stellar mergers (two evolved stars spiraling together because of the radiation of gravitational waves). Such mergers are likely to be messy, leaving behind a remnant disk rich in heavy elements (since the stars are evolved stars composed primarily of Carbon and Oxygen). We intend to search for infrared radiation that results when such a disk is illuminated by the central star and reradiates that energy at lower temperatures. If such infrared excesses are indeed observed around these stars, it would indicate an entirely new environment for planet formation –– a newly formed disk composed of the ashes of old, burnt–out stars.

Roadmap Objectives

- ***Objective No. 1.2:*** Indirect and direct astronomical observations of extrasolar habitable planets

Mission Involvement

Mission Class*	***Mission Name (for class 1 or 2) OR Concept (for class 3)***	***Type of Involvement*****
1	Spitzer	Research or Analysis Techniques

* Mission Class: Select 1 of 3 Mission Class types below to classify your project:
1. Now flying OR Funded & in development (e.g., Mars Odyssey, MER 2003, Kepler)
2. Named mission under study / in development, but not yet funded (e.g., TPF, Mars Lander 2009)
3. Long–lead future mission / societal issues (e.g., far–future Mars or Europa, biomarkers, life definition)

** Type of Involvement = Role / Relationship with Mission
Specify one (or more) of the following: PI, Co–I, Science Team member, planning support, data analysis, background research, instrument/payload development, research or analysis techniques, other (specify).

Astronomical viewing time granted to project researcher.

Cross Team Collaborations

Sara Seager and James Cho, Carnegie Institution of Washington's DTM;
Steinn Sigurdsson, Penn State.